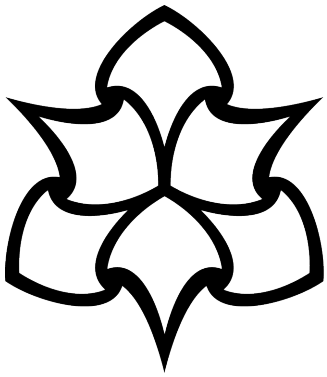

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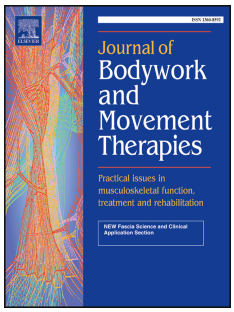

Trait anxiety and sensory processing profile characteristics in patients with non-specific chronic low back pain and central sensitisation - A pilot observational study

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Trait anxiety and sensory processing profile characteristics in patients with non-specific chronic low back pain and central sensitisation - A pilot observational study

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ABSTRACT

Introduction: People with non-specific chronic low back pain (NSCLBP) and central sensitisation (CS) exhibit sensory processing alterations, somatosensory hypersensitivity and differences in the brain's emotional networks. The concept that CS relates to pre-morbid trait sensory processing and anxiety characteristics is unknown.

The aims of this pilot observational study were to test concept plausibility in a NSCLBP population with central sensitisation by investigating:

1) the range of Central Sensitisation Inventory scores, to determine the extent of symptoms of central sensitisation, 2) whether there are identifiable patient characteristics of trait anxiety and trait sensory profile differences; and 3) whether potential relationships exist between trait anxiety, trait sensory profiles and the extent of symptoms of central sensitisation.

Methods: People with NSCLBP and CS were recruited from physiotherapy outpatient clinics in New Zealand and the United Kingdom. Outcomes included the Central Sensitisation Inventory (CSI), Adolescent/Adult Sensory Profile and the State/Trait Anxiety Inventory (trait section) with the Marlow Crown Sociable Desirability Scale. Descriptive and non-parametric tests for correlation were used to analyse the data, p=<0.05.

Results: Of the 21 people recruited, 16 (76.2%) had CSI scores ≥40 in association with 1) an abnormally high prevalence of extreme scores of a) high trait Sensory Sensitive, Sensation Avoiding and Low Registration sensory profiles and b) low trait Sensation Seeking profile, 2) high trait anxiety sub-types and 3) minimal low trait anxiety. Moderate correlations were identified between trait sensory profiles and 1) CS pain (Sensory Sensitive R= 0.57, p<0.01,

CI= 0.07 to 0.88, p<0.01, Sensation Seeking R= -0.47, p<.05, CI= -0.72 to -0.02) and 2) trait anxiety (Sensory sensitive: R=0.65, p<.01, CI= 0.27 to 0.91) and Low Registration (R=.49, p<.05, CI= 0.03 to 0.84). The CSI scores moderately correlated with trait anxiety (R= 0.63, p<0.01, CI= 0.22 to 0.86).

Conclusion: These results provide concept plausibility that the extent of CS pain in people with NSCLBP might be associated with pre-morbid trait anxiety sub-types and abnormal trait sensory processing profiles. A larger study to confirm the findings is warranted.

Key words: Central sensitisation pain; Chronic low back pain; Sensory processing profiles; Trait Anxiety

INTRODUCTION

Chronic low back pain is a significant health problem as well as an economic burden worldwide (Manchikanti et al., 2009). A proportion of people with non-specific chronic low back pain experience pain arising from a predominantly central sensitisation pain mechanism (Nijs et al., 2015) and this is associated with sensory processing alterations (Wand et al., 2011). In recent years, there has been considerable growth in the understanding of pain mechanisms, now broadly classified into three groups: nociceptive pain, neuropathic pain and central sensitisation pain (Nijs et al., 2014). Symptoms resulting from central sensitisation (CS) tend to be disproportional to the extent of tissue pathology (Nijs et al., 2010; Smart et al., 2012), and may even be experienced in the absence of tissue pathology (Moseley and Butler, 2015). Pain associated with central sensitisation results from an augmentation of responsiveness of central neurons to input from unimodal and polymodal receptors (Mayer et al., 2012), characterised by generalised hypersensitivity of

the somatosensory system (Nijs et al., 2010). Central sensitisation involves facilitation of peripheral stimulus processing and alterations in descending inhibitory control of nociceptive input to the brain (Woolf, 2011).

Central sensitisation is considered to be a dominant mechanism common to many chronic musculoskeletal pain conditions including a proportion of people with non-specific chronic low back pain (NSCLBP). Central sensitisation is regarded as the pain mechanism most difficult to treat (Latremoliere and Woolf, 2009), which may be partly due to the paucity of evidence underpinning its aetiology.

In addition to sensitisation of the central nervous system, people with predominant CS pain exhibit cortical disinhibition and neurological disruption resulting in sensory processing alterations (Moseley and Flor, 2012). Patients with NSCLBP exhibit these sensory processing alterations (Wand et al., 2010; Wand et al., 2013) and differences in the brain's neural activation networks compared with recovered back pain patients (Erpelding et al., 2012); (Mansour et al., 2013). It could be assumed that sensory processing alterations such as sensory hypersensitivity develop simultaneously with CS pain; an alternative hypothesis, however, is that these alterations were present pre-morbidly.

A recent review found that pre-morbid sensory sensitivity and psychological factors may have predisposed individuals to CS in some chronic musculoskeletal pain populations (Clark

et al., 2017). The hypothesis underpinning this study, therefore is that pre-morbid sensory sensitivity and psychological factors may be related to individual trait characteristics, such as trait sensory sensitivity and trait anxiety.

Trait sensory sensitivity forms a component of individual trait sensory profiles (Brown et al., 2001; Engel-Yeger and Dunn, 2011b). Trait sensory profiles are a measurement of individual neural thresholds and behavioural responses to sensory stimulation and can be used to identify individual differences in sensory processing function (Dunn, 1997; Brown et al., 2001).

Sensory processing is the registering, modulating and organising of sensory information from the environment (Brown et al., 2001) and creating an appropriate response output (Davies et al., 2009). Sensory input is received from cutaneous tactile receptors, muscle spindles and golgi tendon organs, mechanoreceptors, the vestibular apparatus, the auditory, olfactory, gustatory and visual systems (Davies et al., 2009) and cerebral efferent connections including connections from emotional and psychological networks (Aron et al., 2012). Key components of sensory processing are the neural thresholds for sensory reception (sensory sensitivity) and the behavioural response to sensory stimulation, which vary between individuals based on trait sensory profile characteristics (Dunn, 1997).

The range of neural thresholds for receiving sensory information sits on a continuum from high threshold [hypo-sensitive] to low threshold [hyper-sensitive],(Dunn and Brown, 1997; Dunn, 2001). Cross sectional studies of healthy (non-pain) populations show a normal distribution curve of sensory sensitivity from high to low neural thresholds (Brown et al., 2001). The behavioural response to received sensory stimuli, dependant on neural thresholds, is on a continuum ranging between passive and active (Brown et al., 2001). The response continuum is associated with how an individual adapts to sensory input, either actively or passively, by increasing or decreasing input as necessary, in order to function comfortably.

According to Brown et al., (2001) some people have high sensory thresholds as a trait characteristic, in association with sensory hypo-sensitivity. Similarly, sensory hypo-sensitivity to some sensory stimuli has been found in some people with chronic limb pain (Moseley et al., 2008) and non-specific chronic low back pain (Moseley et al., 2008; Wand et al., 2010). It is possible, therefore, that some of the sensory processing alterations observed in these chronic pain populations may involve trait sensory hypo-sensitivity. People with trait sensory hypo-sensitivity may not score as highly on the Central Sensitisation Inventory (CSI, score<40) yet still exhibit a predominantly non-nociceptive, non-neuropathic pain mechanism, inferring a central sensitisation pain mechanism and this was taken into consideration in the development of the methods for this study.

High trait anxiety is associated with high trait sensory sensitivity (Engel-Yeger and Dunn, 2011b), and central sensitisation, including those with NSCLBP (Franklin, 2014). A common link between anxiety and sensory sensitivity is the low threshold of sensitivity to stimuli (Ristic and Landry, 2015). Those with anxiety and high sensory sensitivity exhibit

physiological differences involving impaired inhibitory control mechanisms and impaired cognitive function (Ansari and Derakshan, 2011b), similar to people with central sensitisation (Latremoliere and Woolf, 2009; Nijs et al., 2010; Berryman et al., 2013). Therefore, identification of trait anxiety and sensory profile characteristics might help understand the aetiology of central sensitisation in patients with NSCLBP and in turn help clinicians sub-classify patients who are at risk of developing central sensitisation.

The aims of this pilot observational study were to test concept plausibility in a NSCLBP population with central sensitisation by investigating:

1) the range of Central Sensitisation Inventory scores, to determine the extent of symptoms of central sensitisation, across the group,

2) whether there are identifiable patient characteristics of trait anxiety and trait sensory profile differences; and

3) whether potential relationships exist between trait anxiety, trait sensory profiles and the extent of symptoms of central sensitisation.

METHODS

This research is presented according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (Vandenbroucke et al., 2007).

Design

A cross sectional observational study design was implemented (Robson and Colin, 2002). Ethical approval was obtained from Manchester Metropolitan University, UK (ref:1205) and permission was given from the Northern Y Ethics Committee, New Zealand.

Sample

A sample size of n=20, approximately 10% of the predicted sample required for the full study was calculated (Thabane, 2004) . Sample size was calculated based on 9 variables (4 sensory profile scores, 4 anxiety sub-types and the CSI score variables) and 20 participants per variable, as recommended for a correlation study (Field, 2009).

Patients with NSCLBP were recruited from physiotherapy clinics in New Zealand and the United Kingdom between July 2014 and March 2015.

Inclusion and exclusion criteria (Table 1) were derived from the literature (Nijs et al., 2014) and were chosen to select people with NSCLBP exhibiting a predominantly central sensitisation pain mechanism. Allowing for the possibility that some people with a predominantly non-nociceptive, non-neuropathic pain mechanism may have a trait sensory hypo-sensitivity profile (Brown et al., 2001), the Central Sensitisation Inventory was not used as a screening tool for inclusion. Instead, the range of CSI scores across the group was investigated as part of the study.

Place table 1 here

Table 1. Inclusion and exclusion criteria given to all healthcare providers involved in participant recruitment.

All participants satisfying the inclusion criteria received a participant information sheet from their clinician. Consent was obtained at a subsequent visit by the same clinician. Participants

were asked to complete four questionnaires. The time required to complete the questionnaires was approximately 15 minutes and participants were given the option of completing them at home or at the clinic. For omitted or ambiguously answered questions participants were contacted by telephone by a third-party administrator to clarify responses.

Outcome Measures

The Central Sensitisation Inventory (CSI)

The CSI (Mayer et al., 2012) (Neblett et al., 2013) measures the extent to which the person's symptoms are likely to be attributable to central sensitisation. This is a two-part questionnaire: Part A has 25 symptom related items scored on a Likert scale (0-4, score range 0-100) and Part B lists 10 conditions known to be related to central sensitivity syndromes (scored 0-1, range 0-10). The CSI has been shown to be valid and reliable with a test-retest reliability of 0.82 and Chronbach's Alpha of 0.88 (Mayer et al., 2012), sensitivity of 81% and specificity of 75% (Neblett et al., 2013). Neblett categorised the CSI scores into clinically relevant symptom severity attributable to central sensitisation, whereby 0-20 is sub-clinical, 21-40 is mild, 41-50 is moderate, 51-60 is severe and 61-100 is extreme (Neblett et al., 2016).

The Adolescent / Adult Sensory Profile questionnaire (AASP)

The AASP measures a component of sensory processing function (Brown and Dunn, 2002) and identifies trait sensory sensitivity profiles. For healthy function, an individual requires an optimum level of sensory stimuli and feedback, without which function might be

compromised (Dunn, 1997). Insufficient or excessive sensory stimuli require behavioural adaptation in order to maintain optimum sensory stimulation and feedback.

The AASP assesses the sensory profiles of adolescents and adults based on Dunn's original model of sensory processing (Dunn, 1997). The AASP combines the sensory thresholds with behavioural response continua and provides a summary score for each sensory profile. These sensory profiles are: Sensory Sensitive (SSv), Sensation Avoidance (SAv), Low Registration (LR) and Sensation Seeking (SSk), summarised in Table 2. The AASP is a 60 item questionnaire and uses a Likert scale of responses ranging from: 'much less than normal', 'less than normal', 'normal', 'more than normal' and 'much more than normal', scored 1 to 5 respectively. Questions related to each of the four sensory profiles are sorted into the profile columns and the sum total for each profile is calculated accordingly. Normal score values for each profile have been established in a healthy population (N= 495; Brown and Dunn, 2002), and acceptable reliability was found for each sensory profile with coefficient alphas of: SSv = 0.81; Sav = 0.66; LR = 0.82 and SSk = 0.79 (Brown and Dunn, 2002). The coefficient alpha in 615 adult patients ranged from 0.66-0.82, consisting of psychology and occupational therapy students from a large mid-west university in the United States. Factor analysis for all four profiles is supportive of Dunn's original sensory profile model (Dunn, 1997).

Place Table 2 here

Table 2: Sensory Profiles identified by the Adult / Adolescent Sensory Profile Questionnaire (Adapted from Brown and Dunn, 2002).

The State-Trait Anxiety Inventory (STAI-T)

The STAI-T (Speilberger and Vagg, 1984), measures a patient's trait anxiety. Trait anxiety is an enduring, relatively stable character trait and is an indicator of the likelihood of the patient responding to perceived threats with (transient) state anxiety. The STAI-T is a 20-item questionnaire, scored 0-80 using a 1- to 4-point Likert scale with answers ranging from "almost never" to "almost always". Internal consistency coefficients range from 0.86 to 0.95 and test-retest reliability coefficients range from 0.65 to 0.75 over a 2-month interval (Speilberger and Vagg, 1984).

The Marlowe Crowne Social Desirability Scale (MCSDS)

The MCSDS (Crowne and Marlowe, 1960) measures defensiveness / social desirability and may be used in conjunction with the STAI-T to identify a coping style or anxiety sub-type. It is useful when using self-report measures for data collection as it identifies people who are more likely to under-report socially undesirable information about themselves (Myers, 2010; Reynolds, 1982). High scorers in defensiveness might under-report levels of anxiety or sensory sensitivity and so the MCSDS was included in the current study.

The Short Form version, (Strahan and Gerbasi, 1972), is a validated 10-item questionnaire answered by "true" or "false", scored 0-10. An internal consistency alpha coefficient has been reported as 0.66 (Reynolds, 1982) and a correlation coefficient of $r = 0.90$ ($p < 0.001$) was reported between the 10 item MCSDS and the original 33 item MCSDS (Crowne & Marlowe, 1960). The Short form 10 item MCSDS was therefore chosen and deemed more time efficient for the participants' usage.

The four anxiety sub-types identified using the MCSDS combined with the STAI-T (Weinberger, 1979; Eysenck and M, 1997) were: High Anxious (HA), Defensive High Anxious (DHA), Low Anxious (LA), and Repressor (Rep), summarised in Table 3.

Place Table 3 here

Table 3: Anxiety sub-types identified by combining the Trait section of the State-Trait Anxiety Inventory, (Speilberger and Vagg, 1984) and the Marlowe-Crowne Social Desirability Scale (Crowne and Marlow, 1960)

Analysis

All data were analysed using IBM SPSS Statistics version 22 (Corp., 2013). Means (SD) were used to describe the range of CSI scores in NSCLBP patients. To determine whether there are identifiable patient characteristics of trait anxiety and trait sensory profile differences in the sample, the prevalence of participants with extreme sensory profile scores was investigated in different sub-groups: High and low CSI scorers and the four anxiety sub-types. The primary outcome measure chosen was the sensory profile scores, trait sensory hypersensitivity being the key outcome of interest.

As the data were ordinal, Spearman's correlation coefficient test was used to determine relationships between CSI scores, patient characteristics of trait anxiety and trait sensory profile scores. Significance was set at 0.05.

RESULTS

Demographics

Of the 22 patients invited to participate the total number included in the study was 21 (n=16 females, n=5 males). One patient did not complete the questionnaires and could not be contacted. Mean age was 43 years (range 20-64). No-one refused to participate, as the questionnaires were part of usual care in the physiotherapy clinics.

Range of Scores on the Central Sensitisation Inventory

The CSI scores were normally distributed (Shapiro Wilk test p=0.35) and ranged from 3 to 92 across the group. N=16 out of 21 (76%) participants scored 40 or more, which is the cut-off, indicating that their symptoms were attributable to central sensitisation (Neblett et al., 2013; Fig. 1). In this NSCLBP population, the scores range from sub-clinical to severe in accordance with the clinically relevant severity levels stipulated by Neblett et al., (2016).

Place figure 1 here

Figure 1: CSI scores for the group of NSCLP patients (>=40 shows greater likelihood that symptoms are attributable to central sensitisation).

Identification of differences in trait sensory profiles and anxiety characteristics

The prevalence of extreme (± 1SD) sensory hypersensitivity profile scores (SAv and SSv) was calculated for both the high (≥40) CSI scoring, and the low (<40) CSI scoring groups. The prevalence normal (within 1 SD) and extreme (± 1SD) scores for each sensory profile in the healthy population (Brown and Dunn, 2002), was used as a reference to calculate the extreme scores in the sample population (Table 4). The results are as follows:

1) Trait sensory hyper-sensitivity profiles in the high CSI scoring group.

The highly sensitised group (n=16 [76%] with CSI scores >=40) showed a higher prevalence of extreme scores for high trait sensory hyper-sensitivity profiles, SAv = 43% (Table 4) and SSv = 62% (Table 5). This is higher than 16% reported in the non-sensitised healthy population (Brown and Dunn, 2002). We interpreted this as meaning that participants with high CSI scores have high trait sensory hyper-sensitivity and either actively avoid excess stimulation (SAv) or passively receive excess stimulation (SSv) more or much more than most. One participant scored lower in SAv (Table 4) meaning they were trait sensory hyper-sensitive, but actively avoided excess stimulation less than others.

2) Sensory hypo-sensitivity in the high CSI scoring group.

The highly sensitised group (n=16 [76%] with CSI scores ≥40;) showed a higher prevalence of extreme scores for trait sensory hypo-sensitivity profiles, (-1 SD) SSk = 31% (Table 6), and (+1 SD) LR = 31% (Table 7). We interpreted this as meaning that those with high CSI scores have high trait sensory hypo-sensitivity and either actively seek stimulation (SSk) less, or much less than most, or respond passively to being under-stimulated more, or much more, than most (LR).

3) Sensory hyper-sensitivity in the low CSI scoring group.

Out of participants with a CSI score of <40 (n=5 [24%]), no-one had an extreme SAv score (Table 4). One participant had a SSv score of -1 ±SD (Table 5). All other participants scored within normal range of trait sensory hyper-sensitivity, reflecting the healthy population.

4) Sensory hypo-sensitivity in the low CSI scoring group.

Out of participants with a CSI score of <40 (n=5, [24%]), 40% had high extreme scores (+1 SD) in SSk (Table 6) and 60% had low extreme scores (-1SD) in LR (Table 7). Both of which are considerably greater than the 16% prevalence found in a healthy non-sensitised population (Brown and Dunn, 2002). We interpreted this as meaning that the low CSI scoring group shows trait sensory hypo-sensitivity, and they either actively seek sensation to compensate more, or much more, than most (SSk), and they miss some sensory information but less than most (LR; Brown and Dunn, 2002).

Place table 4 here
Table 4: Prevalence of Sensation Avoidance (SAv) sensory profile extreme scores in high and low CSI scoring groups.

Place table 5 here
Table 5: Prevalence of Sensory Sensitive (SSv) sensory profile extreme scores in high and low CSI scoring groups.

Place table 6 here
Table 6: Prevalence of Sensation Seeking (SSk) sensory profile extreme scores in high and low CSI scoring groups.

Place Table 7 here
Table 7: Prevalence of Low Registration (LR) sensory profile extreme scores in high and low CSI scoring groups.

<u>Sensory Profiles in people with different anxiety sub-types.</u>

Using the same strategy for calculating prevalence using the known prevalence of individuals with normal and extreme scores for each sensory profile in the healthy population (Brown and Dunn, 2002), the participants were grouped according to their anxiety sub-type. Results show that:

1) there were no participants with the trait anxiety sub-type of Low Anxiety;
2) there was a greater prevalence of higher extreme SAv scores in those with a Defensive High Anxious (29%), High Anxious (75%) and Repressor (20%) anxiety sub-type, compared with those in the healthy population (16%) (Table 8);
3) there was a greater prevalence of higher extreme Sensory Sensitivity scores in those with a Defensive High Anxious (57%), High Anxious (75%) and Repressor (30%) anxiety sub-type, compared with those in the healthy population (16%) (Table 9);
4) there was a greater prevalence of lower extreme Sensation Seeking scores in those with a Defensive High Anxious (29%) and High Anxious (25%) anxiety sub-type compared with those in the healthy population (16%), and the Repressor group showed a comparable distribution (20% in the higher and lower extremes) (Table 10);
5) there was a higher prevalence of extreme Low Registration scores in those with a High Anxious (75%) anxiety sub-type, and the Repressor group show a greater prevalence of lower extreme scores for LR (20%), compared with those in the healthy population (16%) (Table 11).

Place table 8 here

Table 8: Prevalence of Sensation Avoidance sensory profile extreme scores in each trait anxiety sub-type group.

Place table 9 here

Table 9: Prevalence of Sensory Sensitive sensory profile extreme scores in each trait anxiety sub-type group.

Place table 10 here

Table 10: Prevalence of Sensation Seeking sensory profile extreme scores in each trait anxiety sub-type group.

Place table 11 here

Table 11: Prevalence of Low Registration sensory profile extreme scores in each trait anxiety sub-type group.

Relationships Between Sensory Profiles, Anxiety Sub-Types and CSI Scores

The concept that trait hyper-sensitivity, sensory profiles might correlate with high trait anxiety sub-types and high levels of central sensitisation was explored. Results of the correlation studies showed that trait anxiety was found to moderately correlate with trait sensory profiles: A moderate positive correlation was found between trait anxiety and sensory profiles 1) SSv (R=0.65, p<.01, CI= 0.27 to 0.91) and 2) LR (R=.49, p<.05, CI= 0.03 to 0.84). A moderate negative correlation was found between trait anxiety and the sensory profile SSk (R= -0.47, p<.05, CI= -0.73 to -0.02). No correlation was found between trait anxiety and the SA profile.

A moderate positive correlation was found between the CSI and the sensory profile SSv (R= 0.57, p<0.01, CI= 0.07 to 0.88). A moderate negative correlation was found between the CSI and the sensory profile SSk (R= -0.53 p<.05, CI= -0.76 to -0.21). No correlation was found between the CSI and the sensory profiles LR or the SAv. The CSI scores were also found to moderately correlate with trait anxiety (STAI-T scores; R= 0.627, p<0.01, CI= 0.223 to 0.861). These are summarised in table 12.

Place table 12 here.

Table 12: Correlations between Sensory Profiles and 1) CSI and 2) Trait Anxiety (STAI-T) scores.

DISCUSSION

The aims of this pilot observational study were to test concept plausibility in a NSCLBP population with central sensitisation by investigating 1) the range of Central Sensitisation Inventory scores, to determine the extent of symptoms of central sensitisation, across the group, 2) whether there are identifiable patient characteristics of trait anxiety and trait sensory profile differences; and 3) whether potential relationships exist between trait anxiety, trait sensory profiles and the extent of symptoms of central sensitisation.

In order to investigate CSI scores, participants with NSCLBP were selected based on their pain mechanisms being predominantly non-neuropathic and non-nociceptive. This is in line with the current classification algorithm for identifying central sensitisation, which identifies pain most likely to be related to changes in central pain processing mechanisms, to the exclusion of primarily nociceptive and neuropathic pain (Nijs et al., 2014).

Not all the participants scored ≥40 on the CSI, suggesting that not all were highly sensitised. This raises the question as to whether there may be central sensitisation mechanisms that do not exhibit high sensitisation, or generalised hypersensitivity, whereby centrally sensitised participants score <40 on the CSI. Alternatively, it is possible that some participants were more prone to under-reporting information about themselves on the CSI, characteristic of the defensiveness in their Repressor trait anxiety sub-type. A larger study might determine whether individuals who score low on the CSI, despite being recruited for

their clinical presentation of central sensitisation, also exhibit extreme scores for the Repressor anxiety sub-type.

Of the participants with high levels of sensitisation (CSI ≥40) there was a greater prevalence of higher extreme scores for SAv and SSv and lower extreme scores for SSk. This was also reflected in the moderate positive correlations between the CSI scores and the SSv profile scores and moderate negative correlation between the CSI and the SSk profile scores.

On face value, one might expect increased sensory sensitivity and sensation avoidance and reduced sensation seeking behaviours in individuals with central sensitisation, perhaps in association with fear avoidance and in response to pain. However, trait measures propose that trait characteristics are likely to have been present pre-morbidly and therefore these findings may not be an indication of behavioural responses to pain. Moreover, a sub-group of the highly sensitised participants (CSI ≥40) showed a greater prevalence of higher extreme scores for a sensory hypo-sensitivity profile, LR, which is unexpected in a highly sensitised group. The LR sensory profile indicates trait hypo-sensitivity to some stimuli with a passive response, thereby not actively compensating for a lack of stimulation. This observation might link with the observations of other authors regarding sensory hypo-sensitivity in NSCLBP. (Benedict M. Wand et al., 2010; Benedict M. Wand et al., 2013) reported sensory hypo-sensitivity in the perception of tactile stimuli and a tendency to sensory mislocalisation in patients with NSCLBP, suggestive of possible hypo-sensitivity sensory profiles. These results may challenge the current thinking that central sensitisation always involves sensory hyper-sensitivity. Importantly, this pilot might indicate that there are discrepancies between normal trait sensory sensitivity profiles and those with NSCLBP and central sensitisation.

The prevalence of extreme sensory profile scores in the low CSI group (n=5) are similar to the healthy control group, further supporting our idea that the extreme scores are abnormal and represent a subgroup within the NSCLBP population.

Our results also show that anxiety and anxiety sub-types might be related to central sensitisation. We found that participants with central sensitisation exhibited a form of high trait anxiety sub-typing (DHA; n=6; HA, n=4; Rep, n=6). Although Repressors typically score low in self-report trait anxiety, they have been shown to present with the same high state anxiety physiological changes as HA and DHA in the face of threatening stimuli (Myers, 2010). Our results suggest that Rep might undergo similar physiological changes associated with high anxiety in association with high levels of central sensitisation, physiologically linking them with HA and DHA individuals.

No participants were of a low anxious trait anxiety sub-type. This is in agreement with other studies showing low trait anxiety is not associated with high sensitivity to sensory stimuli (M. W. Eysenck and Byrne, 1992; Derakshan and Eysenck, 2009; Ansari and Derakshan, 2011a). However, high anxiety and central sensitisation have in common a low threshold to various sensory stimuli, which might account for the high CSI scoring group containing all three trait anxiety sub-types that demonstrate the physiological characteristics of high anxiety sensitivity.

A moderate correlation was found between trait anxiety and central sensitisation. This may have been a stronger correlation if the Repressor group were excluded from the calculation. In a larger study, it might be possible to select cases excluding the Rep group and correlate anxiety scores reported by the DHA and HA groups versus the whole group anxiety scores, and the CSI scores.

Interestingly, we found a positive correlation between LR sensory profile and trait anxiety. This was a somewhat unexpected result from a shared physiological mechanism perspective, in so much as high anxiety (Derakshan et al., 2007) and central sensitisation (Nijs et al., 2010, 2014) are both associated with high sensory sensitivity. This is in contrast to the LR sensory profile which is characterised by low sensory sensitivity. This suggests that trait sensory hyper-sensitivity may not be a key factor in linking anxiety with sensory sensitivity and central sensitisation, using a hypothesis of shared physiological mechanisms of hypersensitivity. Instead, there might be wider aspects of sensory processing involved in central sensitisation, perhaps involving sensory perception, and is yet to be understood. Individuals with LR sensory profiles might be a new group of individuals susceptible to central sensitisation but who may not be generally trait hyper-sensitive.

The eligibility criteria allowed accurate identification of participants most likely to have predominantly central sensitisation, in line with other studies (Nijs et al., 2010; 2014; Smart et al., 2012). Despite this, 76% showed clinically relevant levels of central sensitisation. Either the validity of the CSI is to be questioned, particularly in light of self-reporting by Rep

anxiety sub-type characteristics, or the presence of low and sub-clinical levels of central sensitisation (Neblett et al, 2016), in the absence of predominant nociceptive and neuropathic pain, must be considered. To avoid recruitment of patients with predominantly nociceptive or neuropathic pain mechanisms, a comprehensive education in clinical recognition of central sensitisation for the participating clinicians is critical.

Strengths and Limitations

The current study has demonstrated the plausibility of the concepts tested. The study methods were rigorous and reported according to STROBE guidelines (Vandenbroucke et al., 2007). They followed the current clinical recommendations for accurately identifying patients with predominantly central sensitisation, thereby limiting heterogeneity within the sample. Bias was limited through the recruitment of participants by multiple participating clinicians instead of just one principle investigator.

Recruitment was successful with n=21/22 (95%) of participants completing all questionnaires. There was 0.17% (4 out of 2,415 questions) of missing data during completion of the questionnaires. After contacting the participants, 100% of questions were completed allowing for a full data set. No information was available from participating clinicians as to how many potential participants refused to participate. The study recruited more female than male participants, which may also present as a limitation.

The small sample size, although appropriate for a pilot study design, presents as a limitation in terms of the strength of the results. However, the concept of relationships existing

between sensory processing profiles, anxiety sub-types and central sensitisation has been found to be satisfactorily plausible and lays the foundation for a much larger study.

Although the questionnaires claim to measure trait characteristics, validation of the questionnaires longitudinally for stability, and construct validity in specific chronic pain populations would be of value. Despite this, the current study obtained cross-sectional data, which the questionnaires have been validated for. The success of the pilot study has laid the foundation for a much larger investigation into trait characteristics behind the aetiology of central sensitisation.

If trait characteristics contribute to the risk factors that predispose to the development of central sensitisation, clinicians will be ultimately equipped to identify at-risk patients and administer appropriate management from baseline for these individuals, saving resources for clinicians, health care providers and patients alike.

CONCLUSION

This is the first study to investigate the concept that trait anxiety and sensory profile characteristics are related to the development of central sensitisation in people with NSCLBP. High trait sensory hyper-sensitivity and high trait anxiety sub-types are associated with central sensitisation in people with NSCLBP. This information can be assessed at baseline and may help clinicians identify those at risk of developing central sensitisation informing appropriate management and early preventative interventions. A rigorous methodology is in place to study these relationships further.

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FIGURE

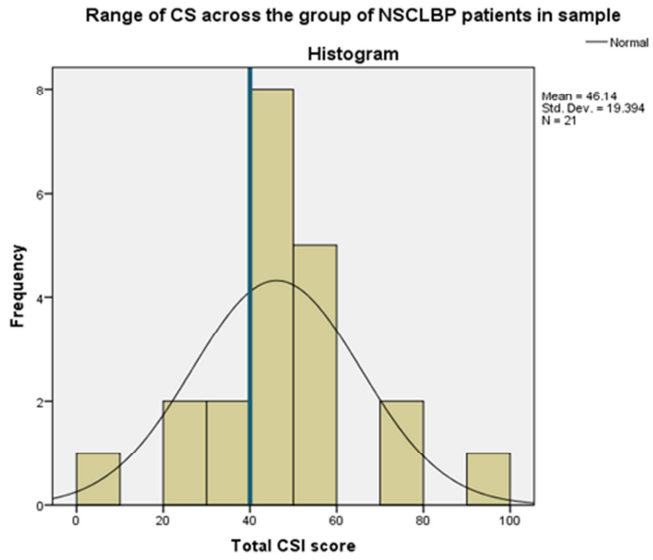

Figure 1: CSI scores for the group of NSCLP patients (>=40 shows greater likelihood that symptoms are attributable to central sensitisation).

TABLES

Table 1. Inclusion and exclusion criteria given to all healthcare providers involved in participant recruitment.

Inclusion Criteria
Aged 18-64 years inclusive.
Reported low back pain most days for more than 6 months.
No clear diagnosis as to the specific source of the pain (such as malignancy/ infection/ inflammatory disease like ankylosing spondylitis etc.) and where anti-inflammatory (NSAID) medication had been used these had not been found to be significantly helpful for the pain.
Pain disproportionate to the current extent of the injury or pathology (i.e. moderate to high pain intensity, unexpected after the normal tissue healing time-frame.)
Pain in variable areas around the back +/- other body parts and that was not always in the same place, with a pain distribution that was not neuro-anatomically logical.
Exclusion criteria
Pain that is predominantly neuropathic in origin (determined using the S-LANSS neuropathic pain score)
Pain that is predominantly nociceptive in origin (clear aggravating / easing factors and responds well to NSAIDs if used)
Pregnancy and/or having given birth in the past 12 months
Spinal surgery within the last 12 months
Any rheumatic disease, neurological disease, cardiac, respiratory, metabolic or endocrine

disorder

Table 2: Sensory Profiles identified by the Adult / Adolescent Sensory Profile Questionnaire (Adapted from Brown and Dunn, 2002).

Stimulus Threshold		*Behavioural response*	
		Active Behavioural Response	Passive Behavioural Response
	High	Sensory Seeker (SSk)	Low Registration (LR)
	Low	Sensation Avoiding (SAv)	Sensory Sensitive (SSv)

Table 3: Anxiety sub-types identified by combining the Trait section of the State-Trait Anxiety Inventory, (Speilberger and Vagg, 1984) and the Marlowe-Crowne Social Desirability Scale (Crowne and Marlow, 1960)

Trait Anxiety	*Social Desirability / Defensiveness*	
	High	Low
High	Defensive High Anxious (DHA)	High Anxious (HA)
Low	Repressor (Rep)	Low Anxious (LA)

Table 4: Prevalence of Sensation Avoidance (SAv) sensory profile extreme scores in high and low CSI scoring groups.

		Sensation Avoidance (SAv)		
		-1SD	**68%**	**+1SD**
CSI >=40 N=16	Range	44-45	45-53	54-55
	n=	1	8	7
	Prevalence (%)	6	50	43
CSI <40 N=5	Range	28	28-36 Mean 32 +-SD 34	36
	n=	0	5	0
	Prevalence (%)	0	100	0

Table 5: Prevalence of Sensory Sensitive (SSv) sensory profile extreme scores in high and low CSI scoring groups.

		Sensory Sensitive (SSv)		
		-1SD	**68%**	**+1SD**
CSI >=40 N=16	Range (Mean 42 +-SD7)	32-34	35-49	50-53
	n=	0	6	10
	Prevalence (%)	0	38	62
CSI<40 N=5	Range (mean 30+-SD5)	23-24	25-35	35
	n=	1	4	0
	Prevalence (%)	20	80	0

Table 6: Prevalence of Sensation Seeking (SSk) sensory profile extreme scores in high and low CSI scoring groups.

		Sensation Seeking (SSk)		
		-1SD	**68%**	**+1SD**
CSI >=40 N=16	Range (mean 46 +- SD8)	25-37	38-52	53-56
	n=	5	11	0
	Prevalence (%)	31	69	0
CSI<40 N=5	Range (mean 56 +- SD8)	47	48-64	56-68
	N=	0	3	2
	Prevalence (%)	0	60	40

Table 7: Prevalence of Low Registration (LR) sensory profile extreme scores in high and low CSI scoring groups.

		Low Registration (LR)		
		-1SD	**68%**	**+1SD**
CSI>=40 N=16	Range (mean 32 +- SD7)	18-24	25-39	40-47
	n=	2	9	5
	Prevalence (%)	13	56	31
CSI<40 N=5	Range (mean 24 +- SD6)	18	18-30	31-34
	n=	3	2	0
	Prevalence (%)	60	40	0

CSI = Central Sensitisation Inventory. SD = Standard Deviation

Table 8: Prevalence of Sensation Avoidance sensory profile extreme scores in each trait anxiety sub-type group.

		Sensation Avoidance (SAv)		
		-1SD	**68%**	**+1SD**
DHA (STAI >=39, MC>5) N=7	Range	26-28	29-46	47-53
	n=	1	4	2
	Prevalence (%)	14	57	29
HA (STAI >=39, MC<=5) N=4	Range	30-33	34-55	55-55
	n=	0	1	3
	Prevalence (%)	0	25	75%
Rep (STAI <39, MC>5) N=10	Range	28	28-44	45-52
	n=	0	8	2
	Prevalence (%)	0	80	20

DHA=Defensive High Anxious; HA=High Anxious; Rep=Repressor.

Table 9: Prevalence of Sensory Sensitive sensory profile extreme scores in each trait anxiety sub-type group.

		Sensory Sensitive (SSv)		
		-1SD	**68%**	**+1SD**
DHA (STAI >=39, MC>5) N=7	Range	32	33-49	49-52
	n=	0	3	4
	Prevalence (%)	0	43	57
HA (STAI >=39, MC<=5) N=4	Range	41	41-51	52-53
	n=	0	1	3
	Prevalence (%)	0	25	75
Rep (STAI <39, MC>5) N=10	Range	23-27	28-42	43-44
	n=	1	6	3
	Prevalence (%)	10	60	30

DHA=Defensive High Anxious; HA=High Anxious; Rep=Repressor.

Table 10: Prevalence of Sensation Seeking sensory profile extreme scores in each trait anxiety sub-type group.

		Sensation Seeking (SSk)		
		-1SD	**68%**	**+1SD**
DHA (STAI >=39, MC>5) N=7	Range	42	43-51	51-53
	n=	2	5	0
	Prevalence (%)	29	71	0
HA (STAI >=39, MC<=5) N=4	Range	25-31	32-58	53
	N=	1	3	0
	Prevalence (%)	25	75	0
Rep (STAI <39, MC>5) N=10	Range	34-40	41-61	62-68
	N=	2	6	2
	Prevalence (%)	20	60	20

DHA=Defensive High Anxious; HA=High Anxious; Rep=Repressor.

Table 11: Prevalence of Low Registration sensory profile extreme scores in each trait anxiety sub-type group.

		Low Registration (LR)		
		-1SD	**68%**	**+1SD**
DHA (STAI >=39, MC>5) N=7	Range	18-23	24-38	38
	n=	1	5	1
	Prevalence (%)	14	72	14
HA (STAI >=39, MC<=5) N=4	Range	32-33	33-45	46-47
	n=	0	1	3
	Prevalence (%)	0	25	75
Rep (STAI <39, MC>5) N=10	Range	18-19	20-34	35-40
	n=	4	5	1
	Prevalence (%)	40	50	10

DHA=Defensive High Anxious; HA=High Anxious; Rep=Repressor.

Table 12: Correlations between Sensory Profiles and 1) CSI and 2) Trait Anxiety (STAI-T) scores.

	Sensory Sensitive	**Sensation Avoiding**	**Sensation Seeking**	**Low Registration**
CSI Scores	R= 0.57, p<0.01, (CI= 0.07 to 0.88)	None	R= -0.53 p<.05, (CI= -0.76 to -0.21)	None
STAI-T Scores	R=0.65, p<.01, (CI= 0.27 to 0.91)	None	R= -0.47, p<.05, (CI= -0.73 to -0.02)	R=.49, p<.05, (CI= 0.03 to 0.84)